# Pupillary Dilatation and Driving in Diabetic Patients

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**Diabetic patients routinely have their pupils dilated for fundoscopy as part of the annual review. To assess the ability of diabetic patients to drive after pupillary dilatation we studied 61 diabetic patients (18 IDDM, 43 NIDDM), mean age 54.98 years, before and 1 h after pupillary dilatation with 1 % tropicamide. Binocular visual acuity (BVA) and contrast sensitivity were checked without glare, with glare, and with glare and sunglasses. Glare was introduced using a 60 W bulb in all 61 patients and with a 500 W bulb in 37 of these patients. Prior to dilatation all 61 patients had a BVA of 6/9 or better. A significant reduction in BVA was found post-dilatation ($p = 0.005$) and 4 out of the 61 patients (6.56 %) had a post-dilatation BVA of less than 6/9. The 60 W glare source caused a significant reduction in BVA pre-dilatation ($p < 0.05$), but not the 500 W glare. With glare, post-dilatation BVA reduced further, resulting in 6 and 7 patients having a BVA of less than 6/9 with the 60 W and 500 W glare source, respectively. The addition of sunglasses with glare did not improve the BVA. No patient with a BVA of 6/5 pre-dilatation reduced to less than 6/9 post-dilatation. No significant change in contrast sensitivity was found in any of the test conditions. We conclude that patients who meet the visual legal requirements to drive (BVA ≤ 6/9) prior to dilatation may not fulfil them post-dilatation. This has important clinical implications and the time course of the phenomenon requires exploration. Meanwhile, patients need to be warned not to drive after pupillary dilatation when they attend for annual fundoscopic examination, certainly for *at least* two hours. © 1998 John Wiley & Sons, Ltd.**

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## Introduction

Diabetes mellitus is an important cause of blindness in the Western world and the most common cause of blindness in adult life.[1] The St Vincent declaration has targeted a reduction to one half the number of diabetic related blindness by 2000 AD.[2] The British Diabetic Association (BDA) guidelines[3] for the prevention of blindness is an annual fundoscopic examination with or without fundal photographs, which should enhance the ability of diabetic services to achieve the St Vincent declaration target.

For a thorough fundoscopic examination to be performed the pupils have to be dilated.[4] One drop of tropicamide 1 %, an anti-muscarinic mydriatic, administered topically to each eye, is often used to dilate the pupils. Tropicamide also reduces accommodation (focusing power of the eye).[5] Patients are advised not to drive immediately post-dilatation since it may not be safe to do so,[6] because of the reduction of visual acuity that may result and the potential medico-legal consequences. Hence patients who drive to clinic may not have their eyes dilated for examination and are therefore recalled for a further outpatient visit. The legal position is also not clear if a patient had a road traffic accident following pupil dilatation with or without appropriate counselling.

This study was performed to answer two specific questions:

1. What is the effect of pupillary dilatation in diabetic patients on both binocular visual acuity (BVA) and contrast sensitivity?
2. Can diabetic patients fulfill the legal requirement to drive after pupillary dilatation?

## Materials and Methods

Sixty-one diabetic patients attending hospital for a routine diabetic annual review were randomly recruited for the study. As part of the diabetic annual review, patients undergo a detailed fundoscopic examination after pupillary dilatation with 1 % tropicamide. Exclusion criteria were patients who were driving following the outpatient consultation, had glaucoma or previous cataract surgery or had a pre-dilatation BVA of less than 6/9. The study

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was approved by the Ethics Committee of Birmingham Heartlands Hospital and written consent was given by all participants.

Pupil size, visual acuity, visual acuity with glare, visual acuity with glare and sunglasses, contrast sensitivity, contrast sensitivity with glare, and contrast sensitivity with glare and sunglasses were recorded on all 61 participating patients pre-dilatation, then repeated again post-dilatation. All tests were performed binocularly (with both eyes open) and best corrected using spectacles or contact lenses if the patient used them for driving or distant vision. All pre-dilatation tests were performed, then one drop of 1 % tropicamide was instilled into each eye. All patients were then examined in the routine diabetic annual review clinic. Post-dilatation repetition of measurements was performed close to 1 h after instillation of the mydriatic. Each patient was checked pre- and post-dilatation under standard settings and by a single investigator to discount variability. A note was made of the presence of diabetic retinopathy, cataract or other ocular pathology during examination and from patients' records.

Pupillary size was measured in all patients before and 1 h after dilatation using a millimetre scale. For both measurements the same background lighting (overhead fluorescent tube) was left on.

All visual acuity measurements were recorded using a new, internally illuminated, standard Snellen chart viewed at 6 metres. The chart was changed frequently to avoid memorizing letters. The lowest complete line of letters read was counted as the visual acuity.

Contrast sensitivity (CS) was measured using a Pelli-Robson chart.[7] This chart consists of 16 groups of letters, each group with three letters. The letters are of constant size and in each group of similar contrast. The contrast of all the letters in the first group is 100 %. It then decreases by 0.15 log unit for each group. Thus the contrast of the first triplet is 0.00 log units and for the last triplet, 2.25 log units. Both sides of the chart contain a series of different letters in this format. The Pelli-Robson chart was placed 1 metre away from the patient with the middle of the chart at eye level. The patient read the letters, starting with those of high contrast, until one letter of a group of three was incorrectly called. The patient was allowed 15 s before it was decided that he/she could not read a letter from the particular group. The contrast level of the previous group of three letters was then recorded as the subject's CS score. The two sides were used randomly and changed frequently to prevent the patient memorizing the letters.

Glare was introduced with both 60 W bulb (to simulate a dull day) and 500 W photoflood lamp (to simulate a bright day); each being examined separately. All 61 patients had tests performed using a 60 W bulb as the glare source and in addition a 500 W bulb was also used in 37 patients. The 60 W bulb was placed 45 cm away from the bridge of the nose and 45 degrees to the right of the visual axis directed at the pupils. The 500 W photoflood lamp was placed 90 cm away from the patient and 20 degrees to the left of the visual axis and directed at the pupils. The patient was given 10 s to adapt to the glare before the tests were performed. When glare was not introduced the general lighting of the room was provided by an overhead fluorescent light bulb that could not be seen by the patient and provided a mean luminance of 135 cd $m^{-2}$. When glare was introduced the overhead light was left on. The mean luminance was checked at eye level for the 60 W and 500 W bulbs and were found to be 280 cd $m^{-2}$ and 1450 cd $m^{-2}$, respectively. Glare was reduced by using sunglasses which were medium grey tint (non-polaroid), fitted over the patient's own spectacles and were claimed by the manufacturer to reduce glare. The same sunglasses were used throughout the study.

### *Statistical Analysis*

For analysis of data the binocular visual acuities were converted to single numerical figures (e.g. 6/4 = 1, 6/5 = 2, and so on). The contrast sensitivity is measured in log units and was analysed taking the mean of readings of CS relating to the nearest on the Pelli-Robson chart. Paired *t*-tests was used for analysis of groups before and after dilatation with a value of $p < 0.05$ taken as significant.

## Results

Sixty-one patients were entered into the study. All 61 patients had tests performed with the 60 W glare source. Thirty-seven patients also had tests repeated using the 500 W glare source. The characteristics of all patients entered into the study and those who were also tested with the 500 W glare source are shown in Table 1. Demonstrating there was pupil dilatation with tropicamide, pre-dilatation pupil size was $4 \pm 0.5$ mm and post-dilatation pupil size was $7.2 \pm 0.7$ ($p < 0.00001$). However, there was no difference in pupil size pre- or post-dilatation in patients who did and did not worsen their BVA post-dilatation before and after the introduction of glare.

### *Binocular Visual Acuity*

The change in BVA under different test conditions, using the 60 W glare source, is shown in Table 2, and using the 500 W bulb as glare source in Table 3. Dilatation (without addition of glare or sunglasses) did have a significant effect on BVA ($p = 0.005$). Of the 61 patients, BVA reduced by 1 line in 22 patients post-dilatation and in 6 patients by 2 lines.

#### 60 W Glare Source

The change in BVA prior to dilatation with the introduction of 60 W glare was not significant ($p = 0.71$) and with the introduction of glare and sunglasses was

Table 1. Characteristics of all 61 patients entered into the study (who all had tests performed using a 60 W glare source) and those who also had tests performed using a 500 W glare source

| | All patients | Patients tested with 500 W glare source |
|---|---|---|
| Number of patients | 61 | 37 |
| Age (years) | 54.9 (24–80) | 52.3 (24–80) |
| Treatment | | |
| Diet | 9 | 5 |
| OHA | 22 | 18 |
| Insulin | 30 | 14 |
| Duration diabetes (years) | 10.56 (1–40) | 10.24 (1–40) |
| Type of diabetes | | |
| Type 1 | 18 | 12 |
| Type 2 | 43 | 25 |
| Diabetic retinopathy | 11 | 9 |
| Background | 7 | 7 |
| Proliferative | 4 | 2 |
| Had laser therapy | 2 | 1 |
| Early cataracts | 5 | 5 |
| Other ocular pathology | | |
| Macular degeneration | 1 | 1 |
| Macular depigmentation | 1 | 0 |
| Sjogren's syndrome | 1 | 1 |

OHA, oral hypoglycaemic agent.

Table 2. The change in BVA found with different test conditions using the 60 W glare source[a]

| Test conditions | Change in BVA (number of lines) | | | | $p$ value |
|---|---|---|---|---|---|
| | 1 | 0 | –1 | –2 | |
| Pre with 60 WG | 7 | 50 | 4 | 0 | 0.71 |
| Pre with 60 WG + SG | 3 | 42 | 11 | 5 | 0.048 |
| Post without glare | 4 | 29 | 22 | 6 | 0.005 |
| Post with 60 WG | 5 | 26 | 21 | 9 | 0.002 |
| Post with 60 WG + SG | 3 | 22 | 22 | 14 | 0.0002 |

[a]+ve numbers represent an improvement in BVA; –ve numbers a decrease.
Pre, pre-dilatation; Post, post-dilatation; 60 WG, 60 W glare source; SG, sunglasses.
All $p$ values are calculated using the pre-dilatation BVA as a comparison.

just significant ($p = 0.048$). The change in BVA after the introduction of glare and glare and sunglasses post-dilatation was however very significant ($p = 0.0028$; $p = 0.0002$, respectively).

All sixty-one patients had an initial BVA of 6/9 or better (Figure 1). Prior to dilatation no patient showed a drop in BVA to less than 6/9 with the introduction of the 60 W glare source. One patient's BVA dropped from 6/9 to 6/12 when tested with the 60 W glare source and sunglasses prior to dilatation.

After dilatation (without glare or sunglasses) four patients (6.56 %) had a BVA of less than 6/9, i.e 6/12 (Figure 2). One of these had an initial BVA of 6/6 and three 6/9. The introduction of the 60 W glare source

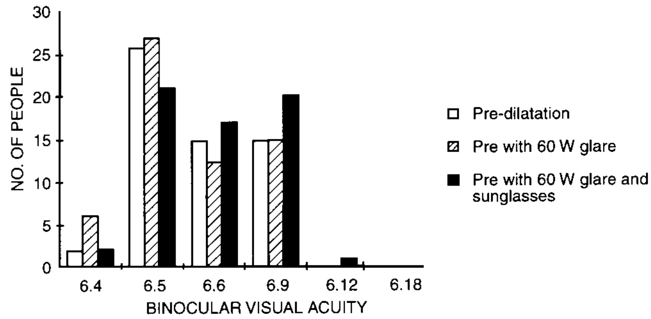


Figure 1. Pre-dilatation binocular visual acuity in the 60 W group; □ background lighting; ▨ 60 W glare source; ■ sunglasses

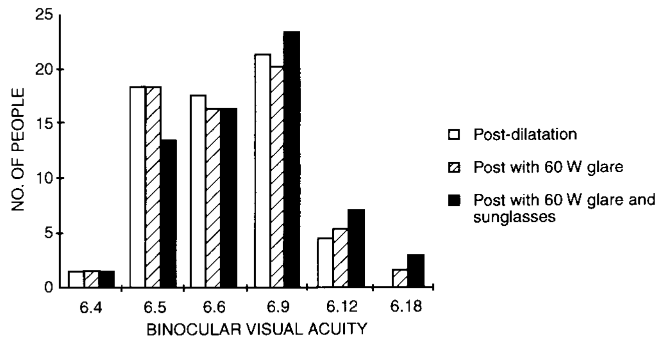


Figure 2. Post-dilatation binocular visual acuity in the 60 W group; key as shown in Figure 1

increased the number of patients with BVA of less than 6/9 to 6 (6/6 to 6/12 in one patient, 6/9 to 6/12 and 6/18 in four and one patient, respectively). With the combination of glare and sunglasses eight patients reduced their BVA to less than 6/9 (6/6 to 6/12 in one patient and 6/9 to 6/12 and 6/18 in five and two patients, respectively). These patients would not meet the legal requirement to drive.

### 500 W Glare Source Group

The change in BVA under different test conditions, using the 500 W glare source, is shown in Table 3.

Table 3. The change in binocular visual acuity found with different test conditions in patients tested using the 500 W glare source[a]

| Test conditions | Change in BVA (number of lines) | | | | | $p$ value |
|---|---|---|---|---|---|---|
| | 1 | 0 | –1 | –2 | –3 | |
| Pre with 500 WG | 4 | 32 | 1 | 0 | 0 | 0.82 |
| Pre with 500 WG + SG | 1 | 23 | 13 | 0 | 0 | 0.075 |
| Post without glare | 0 | 16 | 20 | 1 | 0 | 0.01 |
| Post with 500 WG | 0 | 10 | 21 | 5 | 1 | 0.0002 |
| Post with 500 WG + SG | 1 | 6 | 17 | 12 | 1 | $< 0.00001$ |

[a]+ve numbers represent an improvement in BVA; –ve numbers a decrease.
Pre, pre-dilatation; Post, post-dilatation; 500 WG, 500 W glare source; SG, sunglasses.
All $p$ values are calculated using the pre-dilatation BVA as a comparison.

The introduction of the 500 W glare source and in combination with sunglasses, prior to dilatation, had no significant effect on the BVA ($p = 0.82$; 0.075, respectively). In this smaller group, dilatation, without the addition of glare and sunglasses, had a significant effect on BVA ($p = 0.01$). The introduction of glare and glare with sunglasses further increased this effect ($p = 0.0002$; $p < 0.00001$, respectively).

All thirty-seven patients had an initial BVA of 6/9 or better. Prior to dilatation one patient showed a drop in BVA to less than 6/9 (to 6/12) with the introduction of the 500 W glare source and three patients' BVA dropped from 6/9 to 6/12 when tested with the 500 W glare source and sunglasses.

After dilatation (without glare or sunglasses) three patients had a BVA of less than 6/9 (i.e. 6/12). The introduction of the 500 W glare source and then the glare source and sunglasses increased the number of patients with BVA less than 6/9 to seven (six to 6/12 and one to 6/18; five to 6/12 and two to 6/18, respectively). All of these patients had an initial visual acuity of 6/9.

### *Contrast Sensitivity*

No significant change in the mean contrast sensitivity was found pre- or post-dilatation with any of the test conditions either in the 60 W glare group or in the 500 W glare group.

## Discussion

The importance of annual fundal examination has been stressed by the British Diabetic Association (BDA) to reduce the incidence of blindness and achieve the target put forth in the St Vincent declaration.[2,3]

In our hospital we follow a policy that patients who drive should not have pupil dilatation as recommended by guidelines, e.g. British National Formulary (BNF), with consequent legal implications. It may thus be possible to miss potential eye-sight threatening retinopathy examining the fundus with undilated pupils, and patients may miss the further appointment made to specifically undertake dilated retinal examination.

Vision is critical to driving and visual skills often deteriorate with age, cataract formation, and diabetic retinopathy.[8] Driving-related visual skills are more susceptible in the above subgroups. An improper lookout as an accident cause can be almost three times more likely when the driver has reduced vision rather than with normal vision.[9] The current standard for ordinary car drivers in the UK is the ability to read in good daylight (with the aid of glasses or contact lenses, if worn) a registration mark fixed to a motor vehicle and containing letters and figures 79.4 mm (3.125 inches) high at a distance of 20.5 metres (67 feet).[10] There is no precise Snellen equivalent to the number-plate standard. Notionally the symbol subtense corresponds to a Snellen acuity of about 6/15 (6/16 symbol height, 6/14 limb width). A clinical acuity of this level does not however guarantee that the number-plate symbols will be read correctly, due to the differing symbol format, lighting levels, and other conditions involved. In a study of the visual acuity of those failing the number-plate test, Drasdo and Haggerty[11] suggested that a Snellen acuity standard of 6/9-2 would fail the same proportion of individuals (but not necessarily the same people) as the number-plate test. For this reason it is assumed that to be sure that people would pass the number-plate test, and hence be within legal limits for driving, patients should be able to read 6/9 on the Snellen chart.

Vision can be affected by pupillary dilatation and it is recommended that drivers should refrain from driving for 2 h after dilatation.[6] The action of tropicamide (a mydriatic and cycloplegic) can however last up to 6 h.[5] Previously studies have been performed assessing visual acuity (VA)[12–14] and contrast sensitivity (CS),[13,15] following pupil dilatation, mainly in patients with cataract but none in diabetic patients. Montgomery *et al*.[12] found a significant decrease in VA after pupillary dilatation with 1 % tropicamide. Of 100 eyes examined there was no change in corrected VA in 55 eyes, a drop in one line was found in 41 eyes and 4 eyes displayed a drop in two lines. Nelson and Orton[14] found pupillary dilatation to have only a little effect on VA in healthy young volunteers. Williamson *et al*.[13] found a significant reduction in VA in patients with cataract and healthy control subjects in the presence of glare (without pupillary dilatation). There was however no effect of glare on CS in the cataract subjects. Similarly Buckley *et al*.[15] found no effect of pupillary size on CS function. In our study we found a significant reduction in BVA 1 h after instillation of tropicamide, as has been reported in other studies performed on visual acuity.[12,13] We also found that four patients showed a reduction in their BVA with dilatation to 6/12. One of these had a pre-dilatation BVA of 6/6 and three had a pre-dilatation BVA of 6/9. Therefore a significant number (6.56 %) may not have fulfilled the legal requirements to drive post-dilatation.

Glare plays a major factor while driving. It can cause a reduction in visual efficiency caused by a veiling luminance superimposed on the retinal image resulting in reduction in quality of retinal image, and this may be worsened with the ageing process.[9] No standard method of introducing glare has been reported in the literature. Ideally one would test the BVA using a number plate in broad daylight before and after pupillary dilatation. But because of the inability to maintain a standard setting in this environment we chose to use the 60 W bulb (to simulate a dull day) and 500 W photoflood bulb (to simulate a bright day) as glare sources, as in other studies where different light sources were used to introduce glare. We found the change in BVA prior to dilatation with the introduction of glare was not significant whether a 60 W or 500 W glare source was used. No patients with a BVA of 6/6 had a drop of visual acuity to less

than 6/9 with the lower wattage glare source prior to dilatation, and one patient whose original BVA was 6/9 dropped to 6/12. Post-dilatation the introduction of glare increased the number of people with a BVA of less than 6/9 from 4 to 6 with a 60 W glare source and from 3 to 7 with the 500 W glare source (with one patient in each group dropping to 6/18). It would appear therefore that glare produces a further reduction in BVA post-dilatation.

Sunglasses can be used as protection against glare while driving. Therefore we assessed the utility of sunglasses before and after dilatation in the presence of glare. Prior to dilatation no visual benefit was found with sunglasses. In fact the addition of sunglasses with the glare source was found to reduce the BVA in some patients. This was only slightly significant at 60 W and not significant at 500 W. In both instances prior to dilatation the addition of sunglasses led to an increase in the number of people whose BVA fell to less than 6/9. Post-dilatation sunglasses did not improve the BVA. Therefore sunglasses would not be helpful in terms of BVA and ability to drive post-dilatation.

Contrast sensitivity (CS), the ability to distinguish large targets against their low-contrast backgrounds is also relevant to the visual requirements of driving.[9] Although studies have been done in patients with cataract formation, few studies have been done in diabetic patients. In our study we found that the mean CS did not show a significant reduction after dilatation, a finding which is supported by other studies. No difference was found in CS measurements with luminance[16] or with pupillary dilatation.[15] However one study did find a reduction in CS in patients with diabetic maculopathy.[17] There is also a gradual reduction in contrast sensitivity with ageing which could make elderly diabetic patients at greater risk of road accidents, particularly as there is an age-related reduction in visual acuity and increased prevalence of macular degeneration. Further studies are required to assess reduction of contrast sensitivity in elderly diabetic patients post-pupillary dilatation and in the presence of glare.

In conclusion, we have found that a significant number of diabetic patients may not fulfil the legal requirements to drive after pupillary dilatation even if their pre-dilatation binocular visual acuity is 6/6. More people are unlikely to meet the legal requirements in conditions that cause glare. The use of sunglasses in our data was detrimental to BVA. Some diabetic centres do use dilating drops regardless of whether patients are driving home, but our data support the recommendations that patients be forewarned that they should not drive for at least 2 h after pupillary dilatation for fundoscopic examination. Further studies are required to assess road safety with dynamic visual acuity testing.

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